APPENDIX E

CAPITAL COST: HIGH-SPEED TRAIN ALTERNATIVE

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HIGH-SPEED TRAIN ALTERNATIVE

The estimated total costs for the High-Speed Train (HST) Alternative by region and segment are presented in Table E-1. HST segment cost breakdown is presented in Appendix F.

Table E-1
High-Speed Train Alternative Capital Cost
Includes Contingencies and Program Implementation Cost

Alignment Option by Region and Segment	Segment Length		Average Cost		Segment Cost
	km	miles	$/km	$/miles	
BAY AREA TO MERCED					
San Francisco to San Jose					
Segment 1–TBT (San Francisco)					$1,000,000,000
Segment 2–4th Street (San Francisco)	0.9	0.6	$950,097,010	$1,529,032,922	$855,087,309
Segment 3–Caltrain Shared Use (San Jose)	73.9	45.9	$36,325,285	$58,459,880	$2,684,438,570
Oakland to San Jose					
West Oakland Downtown 7th Street Station (Segment 4)	9.4	5.8	$115,744,736	$186,273,096	$1,088,000,514
Oakland City Center Downtown 12th Street Station (Segment 5)	9.3	5.8	$119,650,633	$192,559,028	$1,112,750,882
Oakland Coliseum Segment (Segment 6)	22.5	14.0	$30,914,172	$49,751,537	$695,568,863
Niles Junction to the Mulford Line (San Jose) (Segment 7)	43.7	27.2	$31,496,334	$50,688,436	$1,376,389,785
Hayward Line to the I-880 (San Jose) (Segment 8)	36.9	22.9	$40,966,197	$65,928,703	$1,511,652,667
San Jose to Los Banos					
Segment 9–(San Jose)	15.6	9.7	$24,164,987	$38,889,777	$376,973,799
Segment 10–(South San Jose)	15.0	9.3	$7,872,537	$12,669,621	$118,088,062
Segment 11–Morgan Hill Station only w/Segment 14 (Gilroy Bypass)	12.8	8.0	$17,804,084	$28,652,895	$227,892,272
Segment 12–Caltrain/Gilroy/ Pacheco Pass Align (Gilroy Station)	25.4	15.8	$27,490,846	$44,242,228	$698,267,492

Alignment Option by Region and Segment		Segment Length		Average Cost		Segment Cost
		km	miles	$/km	$/miles	
	Segment 14–Caltrain/Morgan Hill/Pacheco Pass Align Gilroy Bypass (Morgan Hill Station)	24.5	15.2	$37,455,023	$60,278,016	$918,838,380
	Segment 12 to SR-152 Connection	3.5	2.2	$18,667,537	$30,042,488	$65,747,064
	PB (SR-152 Alignment Option)	33.8	21.0	$60,296,032	$97,037,057	$2,038,488,248
	Segment 13 (Los Banos)	90.8	56.4	$11,542,776	$18,576,297	$1,047,645,412
	Segment 13A (Los Banos Station to High-Speed Loop)	50.8	31.6	$9,640,884	$15,515,499	$490,084,712
	Segment 30 (High-Speed loop)	21.3	13.3	$8,235,192	$13,253,257	$175,771,935
	Segment 31 (High-Speed Loop to Chowchilla Loop)	10.8	6.7	$8,425,078	$13,558,849	$90,990,842
	Segment 32 (Chowchilla Loop)	11.1	6.9	$9,095,170	$14,637,258	$100,856,344
	Segment 33 (Chowchilla Loop to Fairmead)	7.9	4.9	$8,614,696	$13,864,009	$67,926,877
	Segment 34 (Fairmead Loop)	8.2	5.1	$8,746,860	$14,076,707	$72,109,115
San Jose to Merced						
	Segment 9–(San Jose)	15.6	9.7	$24,164,987	$38,889,777	$376,973,799
	PB 1–Diablo Range Direct Rt 130 Align (Northern Alignment Option)	72.7	45.2	$50,721,466	$81,628,287	$3,686,233,259
	PB 2–Diablo Range Direct Min Tunnel Align (Minimize Tunnel Option)	71.5	44.4	$52,629,069	$84,698,277	$3,760,925,919
	PB 3–Diablo Range Direct Incr. Tunnel Align (Tunnel under Park Option)	71.4	44.3	$54,603,463	$87,875,755	$3,895,957,070
	Segment 16 (Merced)	48.5	30.1	$14,115,740	$22,717,082	$684,613,407
	Segment 16A (Hwy 33 to San Joaquin River)	4.4	2.7	$7,890,859	$12,699,107	$34,909,162
	Segment 17 (San Joaquin River to UP Loop)	13.7	8.5	$8,803,684	$14,168,155	$120,786,538
	Segment 18 (High Speed UP Loop)	7.9	5.0	$7,907,962	$12,726,631	$63,168,799
	Segment 19 (High Speed BNSF Loop)	16.8	10.4	$8,595,883	$13,833,732	$144,324,869
	Segment 21 (Between San Joaquin River and Hilmar)	15.0	9.3	$8,785,310	$14,138,586	$131,937,782
	Segment 22 (Delhi Loop)	8.8	5.5	$8,697,633	$13,997,483	$76,391,309
	Segment 23 (Delhi Loop to Livingston Connection)	4.2	2.6	$8,483,168	$13,652,336	$35,714,138
	Segment 24 (Livingston Connection)	11.0	6.9	$9,642,253	$15,517,701	$106,614,387

Alignment Option by Region and Segment	Segment Length		Average Cost		Segment Cost
	km	miles	$/km	$/miles	
SACRAMENTO TO BAKERSFIELD					
Sacramento to Stockton					
UPRR: SAC DT Depot to STO DT Station (Option A1)	147.9	92.0	$23,991,883	$38,611,192	$3,550,318,793
Option A1 Modified (Business Plan Option–Without Storage Leads)	147.9	92.0	$23,081,309	$37,145,766	$3,415,572,083
Option A1 Mod (BP Option–Without Storage Leads or Stockton Loop)	101.9	63.4	$22,478,839	$36,176,184	$2,292,391,982
CCT: SAC DT Depot to STO DT Station (Option A2)	150.8	93.7	$24,286,293	$39,085,000	$3,662,955,876
UPRR: SAC DT Depot to STO DT Station (Option A3)	141.5	87.9	$23,489,340	$37,802,428	$3,323,741,567
CCT: SAC DT Depot to STO DT Station (Option A4)	144.3	89.7	$23,806,869	$38,313,441	$3,436,378,650
UPRR: Power Inn Rd. Station to STO DT Station (Option A5)	135.9	84.5	$21,653,901	$34,848,575	$2,943,198,201
CCT: Power Inn Rd. Station to STO DT Station (Option A6)	139.7	86.8	$21,848,342	$35,161,498	$3,053,087,327
UPRR: Power Inn Rd. Station to STO DT Station (Option A7)	129.4	80.4	$20,987,492	$33,776,094	$2,716,620,974
CCT: Power Inn Rd. Station to STO DT Station (Option A8)	133.3	82.8	$21,210,492	$34,134,977	$2,826,510,101
Stockton to Merced					
Express Loop/UPRR: to Modesto DT Station (Option B1)	54.6	33.9	$28,756,637	$46,279,322	$1,569,249,693
Option B1 Modified (Business Plan Option–No Express Loop)	30.4	18.9	$33,104,824	$53,277,050	$1,006,386,644
Express Loop/BNSF: to Modesto Briggsmore Station (Option B2)	27.8	17.2	$45,229,467	$72,789,772	$1,255,117,716
Modesto to Merced					
UPRR: to Merced DT Station (Option C1)	59.6	37.0	$22,486,897	$36,189,153	$1,340,219,057
UPRR: to Merced DT Station (Option C2)	80.2	49.8	$19,168,165	$30,848,172	$1,536,251,767
UPRR: to Merced DT Station (Option C3)	59.6	37.0	$22,967,324	$36,962,325	$1,369,174,037
UPRR: to Merced DT Station (Option C4)	80.7	50.1	$19,376,534	$31,183,508	$1,562,814,328
BNSF: to Merced DT Station (Option C5)	65.2	40.5	$19,995,884	$32,180,256	$1,304,447,509

Alignment Option by Region and Segment		Segment Length		Average Cost		Segment Cost
		km	miles	$/km	$/miles	
	BNSF: to Merced DT Station (Option C6)	84.7	52.7	$17,876,776	$28,769,882	$1,514,860,095
	BNSF: to Merced DT Station (Option C7)	65.3	40.5	$20,067,325	$32,295,228	$1,309,388,913
	BNSF: to Merced DT Station (Option C8)	85.3	53.0	$17,940,783	$28,872,891	$1,529,415,867
	UPRR: to Merced Municipal Airport Station (Option C9)	60.2	37.4	$17,389,924	$27,986,370	$1,045,934,389
	UPRR: to Merced Municipal Airport Station (Option C10)	60.6	37.7	$17,028,699	$27,405,034	$1,032,637,326
	BNSF: to Merced Municipal Airport Station (Option C11)	66.3	41.2	$15,523,173	$24,982,126	$1,028,456,805
	BNSF: to Merced Municipal Airport Station (Option C12)	66.8	41.5	$15,702,078	$25,270,046	$1,048,082,327
	BNSF: to Castle Air Force Base Station (Option C13)	80.4	50.0	$15,916,267	$25,614,749	$1,279,604,194
	BNSF: to Castle Air Force Base Station (Option C14)	79.4	49.3	$19,207,188	$30,910,973	$1,524,647,384
	BNSF: to Castle Air Force Base Station (Option C15)	80.9	50.3	$16,061,487	$25,848,457	$1,299,229,716
	BNSF: to Castle Air Force Base Station (Option C16)	79.4	49.3	$19,266,041	$31,005,687	$1,529,588,787
Merced to Fresno						
	BNSF: to Fresno DT Station (Option D1)	100.9	62.8	$17,154,526	$27,607,533	$1,732,593,373
	BNSF: to Fresno DT Station (Option D2)	142.2	88.4	$16,993,518	$27,348,417	$2,416,784,203
	BNSF: to Fresno DT Station (Option D3)	92.3	57.3	$17,823,825	$28,684,666	$1,644,625,735
	BNSF: to Fresno DT Station (Option D4)	130.1	80.8	$17,126,298	$27,562,105	$2,228,011,515
	UPRR: to Fresno DT Station (Option D5)	88	54.7	$23,397,979	$37,655,397	$2,059,022,166
	UPRR: to Fresno DT Station (Option D6)	123.7	76.9	$21,464,014	$34,542,983	$2,655,978,587
	UPRR: to Fresno DT Station (Option D7)	96.7	60.1	$22,196,156	$35,721,251	$2,146,989,804
	UPRR: to Fresno DT Station (Option D8)	135.9	84.4	$20,937,919	$33,696,314	$2,844,751,274
Fresno to Tulare						
	UPRR: to Visalia Airport Station (Option E1)	50.0	31.1	$14,386,082	$23,152,154	$719,304,091
	BNSF: to Hanford Station (Option E2)	47.8	29.7	$14,557,377	$23,427,827	$696,090,074

Alignment Option by Region and Segment		Segment Length		Average Cost		Segment Cost
		km	miles	$/km	$/miles	
Tulare to Bakersfield						
	UPRR: to Bakersfield Airport Station (Option F1)	129.5	80.4	$14,560,631	$23,433,065	$1,885,092,142
	UPRR: to Bakersfield Airport Station (Option F2)	116.0	72.1	$14,345,668	$23,087,115	$1,664,097,538
	UPRR (around Tulare): to Bakersfield Airport Station (Option F3)	129.9	80.8	$14,486,519	$23,313,793	$1,882,624,613
	UPRR (around Tulare): to Bakersfield Airport Station (Option F4)	116.5	72.4	$14,263,898	$22,955,519	$1,661,630,010
	BNSF: to Bakersfield Airport Station (Option F5)	143.2	89.0	$12,567,500	$20,225,431	$1,799,917,402
	BNSF: to Bakersfield Airport Station (Option F6)	129.8	80.6	$12,168,493	$19,583,291	$1,578,922,799
	UPRR: to Golden State Station (Option F7)	129.5	80.4	$14,677,457	$23,621,078	$1,900,217,028
	UPRR: to Golden State Station (Option F8)	116.0	72.1	$14,476,055	$23,296,953	$1,679,222,425
	UPRR (around Tulare): to Golden State Station (Option F9)	129.9	80.8	$14,602,903	$23,501,095	$1,897,749,500
	UPRR (around Tulare): to Golden State Station (Option F10)	116.5	72.4	$14,393,734	$23,164,470	$1,676,754,897
	BNSF: to Golden State Station (Option F11)	143.2	89.0	$12,673,106	$20,395,388	$1,815,042,289
	BNSF: to Golden State Station (Option F12)	129.8	80.6	$12,285,058	$19,770,884	$1,594,047,686
	UPRR: to Truxtun (Union Ave Station) (Option F13)	118.1	73.4	$16,711,736	$26,894,932	$1,973,890,000
	UPRR (around Tulare): to Truxtun (Union Ave Station) (Option F14)	118.6	73.7	$16,621,608	$26,749,886	$1,971,422,471
	UPRR :to Truxtun (Amtrak) Station (Option F15)	135.7	84.3	$17,241,322	$27,747,219	$2,338,975,045
	UPRR: to Truxtun (Amtrak) Station (Option F16)	122.2	75.9	$17,332,650	$27,894,196	$2,117,980,441
	UPRR (around Tulare): to Truxtun (Amtrak) Station (Option F17)	136.2	84.6	$17,160,896	$27,617,786	$2,336,507,516
	UPRR (around Tulare): to Truxtun (Amtrak) Station (Option F18)	122.7	76.2	$17,243,030	$27,749,968	$2,115,512,913
	UPRR: to Truxtun (Amtrak) Station (Option F19)	144.4	89.7	$17,597,847	$28,320,989	$2,541,287,432

Alignment Option by Region and Segment		Segment Length		Average Cost		Segment Cost
		km	miles	$/km	$/miles	
	UPRR: to Truxtun (Amtrak) Station (Option F20)	130.9	81.4	$17,719,734	$28,517,147	$2,320,292,828
	UPRR (around Tulare): to Truxtun (Amtrak) Station (Option F21)	144.9	90.0	$17,521,065	$28,197,422	$2,538,819,903
	UPRR (around Tulare): to Truxtun (Amtrak) Station (Option F22)	131.4	81.7	$17,634,631	$28,380,187	$2,317,825,300
	BNSF: to Truxtun (Amtrak) Station (Option F23)	143.9	89.4	$14,976,145	$24,101,769	$2,155,681,265
	BNSF: to Truxtun (Amtrak) Station (Option F24)	130.5	81.1	$14,827,912	$23,863,211	$1,934,686,662
BAKERSFIELD TO LOS ANGELES						
Bakersfield to Sylmar I-5 Corridor						
	I-5 (Wheeler Ridge Corridor) (Option 1.01)	46.0	28.6	$10,521,451	$16,932,634	$483,986,739
	I-5 (Union Avenue Corridor) (Option 1.02)	47.2	29.3	$15,435,861	$24,841,610	$728,572,622
	I-5 Tehachapi Crossing Option (Sylmar) (PB)	90.8	56.4	$63,353,553	$101,957,660	$5,752,819,344
Bakersfield to Sylmar SR-58/SR-14 Corridor						
	SR-58/Soledad Canyon (SR-58 Corridor) (Option 1.03)	14.2	8.8	$14,365,163	$23,118,489	$203,985,313
	SR-58 Alignment Option (PB)	73.8	45.9	$37,309,279	$60,043,464	$2,755,178,312
	SR-58/Soledad Canyon (Antelope Valley Corridor) (Option 2.01)	33.6	20.9	$13,493,307	$21,715,373	$453,510,048
	Soledad Canyon Alignment option (Sylmar) (PB)	55.3	34.3	$40,278,035	$64,821,214	$2,225,240,596
San Fernando Valley						
	Metrolink/UPRR: Begin Alignment to Sylmar Sta (Option 3.01)	0.3	0.2	$18,984,447	$30,552,506	$4,935,956
	Metrolink/UPRR: Sylmar Sta to Burbank Airport Sta (Option 3.02)	10.8	6.7	$40,700,880	$65,501,718	$437,534,465
	Metrolink/UPRR: Burbank Airport Sta to Burbank DT Sta (Option 3.03)	7.5	4.7	$34,888,752	$56,148,003	$261,665,639
	Metrolink/UPRR: DT Burbank Sta to Exist. LAUS or LAUS S. (Under I-5 & SR-110 Variant) (pick from Opts 4.01, 4.02, 4.03) (Opt 3.04A)	18.2	11.3	$44,530,329	$71,664,617	$811,787,891

Alignment Option by Region and Segment		Segment Length		Average Cost		Segment Cost
		km	miles	$/km	$/miles	
	Metrolink/UPRR: DT Burbank Sta to LAUS E. Bank (Under I-5 & SR-110 Variant) (pick Options 4.04B) (Option 3.04B)	16.1	10.0	$44,903,642	$72,265,407	$724,744,786
	Metrolink/UPRR: DT Burbank Sta to Exist. LAUS or LAUS S. (Over I-5 & SR-110 Variant) (pick from Options 4.01, 4.02, 4.03) (Option 3.04C)	18.3	11.4	$41,204,295	$66,311,884	$752,802,463
	Metrolink/UPRR: DT Burbank Sta to LAUS E. Bank (Over I-5 & SR-110 Variant) (pick from Options 4.04A) (Option 3.04D)	16.2	10.1	$42,431,252	$68,286,481	$686,537,656
	I-5: DT Burbank Sta to Exist. LAUS or LAUS S. (Aerial at Silver Lake) (pick from Options 4.01, 4.02, 4.03) (Option 3.04E)	17.3	10.8	$46,076,089	$74,152,278	$798,959,392
	I-5: Beg DT Burbank Sta to Beg Exist LAUS or To Beg LAUS South (Cut & Cover at Silver Lake) (pick from Opt 4.01, 4.02, 4.03) (Opt 3.04F)	17.3	10.8	$53,999,919	$86,904,446	$936,358,594
	Metrolink/UPRR: (Sylmar Metrolink Station) (Option 3.05)	0.0	0.0	$0	$0	$298,860,062
	Metrolink/UPRR: (Burbank Airport Station) (Option 3.06)	0.0	0.0	$0	$0	$592,627,029
	Metrolink/UPRR: (Burbank DT STA Metrolink/UPRR Variant) (Opt 3.07)	0.0	0.0	$0	$0	$291,551,471
	Metrolink/UPRR: (Burbank DT Station I-5 Variant) (Option 3.08)	0.0	0.0	$0	$0	$291,551,471
Los Angeles Union Station						
	Combined I-5/UPRR: (Existing LAUS w/South Connection) (Option 4.01)	5.7	3.6	$89,237,253	$143,613,438	$511,329,460
	Combined I-5/UPRR: (Existing LAUS w/East Connection) (Option 4.02)	5.9	3.7	$85,776,215	$138,043,437	$505,221,906
	Combined I-5/UPRR: (LAUS South) (Option 4.03)	5.2	3.2	$90,733,551	$146,021,495	$474,536,469
	Combined I-5/UPRR: (LAUS East Bank Over 110- FWY variant) (Opt 4.04A)	7.3	4.5	$78,969,142	$127,088,515	$577,264,429

Alignment Option by Region and Segment		Segment Length		Average Cost		Segment Cost
		km	miles	$/km	$/miles	
	Combined I-5/UPRR: (LAUS East Bank Under 110 Fwy) (Option 4.04B)	7.3	4.5	$78,651,488	$126,577,301	$574,942,379
LOS ANGELES TO SAN DIEGO VIA INLAND EMPIRE						
Segment 1						
	1A Colton Line	91.7	57.0	$44,774,631	$72,057,784	$4,104,042,673
	1B UPRR	106.8	66.4	$27,208,490	$43,787,820	$2,906,138,825
	1C San Bernardino Loop	101.6	63.1	$47,396,668	$76,277,543	$4,816,449,401
Segment 2						
	2A Escondido Freeway	118.5	73.6	$33,541,927	$53,980,499	$3,974,718,386
	2B Escondido–Downtown	118.7	73.8	$41,186,959	$66,283,986	$4,888,892,058
Segment 3						
	3A–QualComm	15.2	9.4	$84,260,813	$135,604,634	$1,280,764,357
	3B–San Diego–Carroll Canyon	31.1	19.3	$45,706,837	$73,558,023	$1,421,482,620
	3C–San Diego–Miramar Road	30.7	19.1	$43,935,250	$70,706,931	$1,348,812,167
LOS ANGELES TO SAN DIEGO VIA ORANGE COUNTY						
Option 1						
	LAUS-LAX (elec): MTA Harbor Subdivision	25.4	15.8	$75,923,478	$122,186,993	$1,924,660,161
	LAUS-UP Santa Ana (elec): UPRR/LOSSAN Corridor	44.2	27.4	$78,114,307	$125,712,792	$3,448,746,669
	LAUS-IRV (elec): LA to IRV (LOSSAN)	69.3	43.0	$33,318,203	$53,620,450	$2,307,485,456

Definition of Cost Elements

The capital costs for the proposed HST Alternative have been categorized into discrete cost elements. In general, the capital costs were estimated by determining the appropriate unit costs for the identified cost elements and the cost element quantities from conceptual high-speed train alignment and station option plans prepared for each region. Each cost element is defined below along with the methods and assumptions applied in each case. Many of these elements were reviewed as part of the peer reviews of the Authority's Corridor Evaluation.[1] The unit costs and assumptions were also reviewed and in some cases revised by the regional teams as part of the alignment and station screening performed as part of this program. However, application of these assumptions is consistent with past evaluations and provides appropriate level of detail for the comparison of alignment and station options at this program level.

A. ALIGNMENT COSTS

Track Items

High-Speed Train Track: For steel-wheel-on-steel-rail systems (VHS), this includes ballast, subballast rails, ties, fasteners, etc. No special trackwork (turnouts, sidings, etc.) is included in this cost element. Cost for Special Track work is included as part of the Passenger Station Cost. The track required in the maintenance and service facilities, as well as the at-grade or elevated reinforced concrete substructures/foundation costs, including switches, within maintenance and service facilities are included in the cost of the those facilities.

Track unit costs were applied per unit length of alignment. Unit costs were applied to account for lengths of ballasted track section and direct fixation (slab track). Special trackwork costs were estimated based on Station Configuration.

The "ballasted track" unit cost, applied to most corridors, is $846,282 per km ($1,361,960 per mile) of alignment; this is a double-tracked cost. In areas where a single track is added to the existing corridor, this cost would be one half, $423,141 per km ($680,980 per mile).

For "direct fixation track", the unit cost is given as $1,600,459 per km ($2,575,690 per mile) of alignment. In areas where adding a single track is proposed, this cost would be one half, $800,230 per km ($1,287,845 per mile).

Earthwork and Related Items

Included in the detailed categories below are all the earthwork elements and other items related to site development.

Site Preparation: This includes the costs for "clearing and grubbing," which cover the removal of unsuitable surface debris, and removal of vegetation. This also includes the cost of "grading," which is the movement of dirt around the site to prepare the surface for construction. Site preparation also includes work done to make the site usable after the demolition of existing structures.

[1] *California High-Speed Rail Corridor Evaluation German Peer Review Report (Phase I)*, DE-Consult Deutsche Eisenbahn-Consulting GmbH December 2000.

Review of The Final Report on California High-Speed Rail Corridor Evaluation (Phase I), Japan Railway Technical Service September 2000.

Peer Review – Phase I, SNCF International, October 2000.

Unit costs for site preparation were applied to the total area required for earthwork operations along a given segment. The amount of area was based on the earthwork volume calculations.

Earthwork: The general category of "earthwork" is made up of four constituent activities: excavation, embankment, spoil, and borrow. Earthwork incidental to the construction of a structure, such as the excavation for a bridge foundation, is not included here—that cost is a part of the structural estimates.

Unit costs of earthwork were applied to the total volume of earthwork required along a given segment. A digital terrain model (DTM) was used to calculate the earthwork volumes based on the profile of each segment. If a DTM was unavailable an assumption of 1m (3.28 ft) (depth of cut/fill) by 8.3m (27.2 ft) (the width of the cross-sectional track bed) was assumed to be the required cut/fill quantity.

Landscaping/Erosion Control: This includes areas alongside the tracks within the high-speed train right-of-way. Plantings in station areas are included under passenger stations. The landscaping along the route includes the seeding of cut slopes and embankments. Site preparation and landscaping costs would only be applied to areas of new right-of-way for the alignment, including bypass alignments and corridor widening.

Security Fencing: This is a security chain link fence 2.5m (8.2 ft) in height along the right-of-way. All at-grade sections, trench sections, cut and fill sections, tunnel portals, maintenance areas, and any other areas where tracks are accessible to public would be fully fenced. A unit cost for fencing was applied per length of alignment and includes fencing for both side of right-of-way.

Drainage Facilities: This includes culverts and other structures needed for track and cross drainage purposes only, including track underdrains if needed. This does not include the cost of bridges or bridge drainage costs. The cost of drainage facilities was estimated at 5% of the earthwork cost for each segment.

Structures, Tunnels, and Walls

Structures are defined as those appurtenant elements that require structural engineering for system design, and fall into the categories below. Buildings (such as passenger terminals and maintenance facilities) are not included under structures, but are included other elements.

Viaducts and Bridges: This includes costs for prestressed reinforced concrete aerial structures including the bridge, as well as the abutment (for a bridge or viaduct). Cost for that bridge would consist of the excavation for the abutment including all wing walls and transition slabs. The foundation work is included as well as the earthwork needed to construct the foundations. Waterway crossings that were calculated on a per crossing basis are included under bridge costs.

A unit cost was applied per length of aerial structure. Different unit costs were used for "special structures" requiring spans greater than 120 feet (36.6 meters) and for "high structures with heights exceeding 30 feet (9.1 meters). Unit costs for other special or unique structures (i.e., bay crossing) would be addressed on a case by case basis at the subsequent project level analysis.

High-Speed Train Tunnels & Trenches: This includes tunnel boring machine (TBM) and drill and blast (D&B) tunnels constructed beneath the ground level that only require surface occupation (construction access) at the openings of the tunnel. The costs for these tunnels for the high-speed train system include all structural work, full lining and grouting, ventilation systems, special

drainage, etc. needed to make the tunnel ready to receive the railroad. This item does not include the track, signaling or traction power systems, which are addressed in separate cost elements. Unit costs are applied per unit length of twin single track tunnel sections for two discrete cases: twin single track tunnels less than six miles in total length, and twin single track tunnels greater than 6 miles in total length. Tunnels greater than six miles in total length require a third access tunnel and additional ventilation/cooling facilities and are significantly more expensive.

Cross-over Chambers: This involves an oversized tunnel segment to accommodate universal cross over tracks at an average spacing of ten miles apart (not to exceed 12 miles) in long tunnel sections.

Seismic Chambers: This involves an oversized tunnel segment (3600' long x 77' wide x 37' high) to accommodate potential track realignment and passage of the train subsequent to a possible future fault rupture event along fault zones where especially large displacement is predicted.

Cut & Cover Double Track Tunnel & Trench: Used in Urban areas where depth of alignment is not sufficient for tunneling methods. The cost accounts for all anticipated labor, equipment, and mobilization costs. Cost includes excavation support, excavation bracing, excavation, structural backfill, and structure cost. Excavation includes removing the material from within the supported area and disposing of that amount of material not used for backfill or unsuitable for use. Structural back-fill includes obtaining sufficient, acceptable material for use, and the placing and compacting of that material. Cost does not include, traffic control, street relocation or utility relocation.

Mechanical & Electrical for Tunnels: This includes mechanical and electrical systems related to tunnel (such as lighting, fans, etc.). This is a cost for twin single track TBM length.

Retaining Walls: These are concrete walls used to support embankments and retained fill along cut sections (retaining walls that are a part of abutments for bridges are included in the bridge costs).

Containment Walls: These are structural concrete walls (including foundations and walls) required to prevent incursion of vehicles from one area to another. Generally, they are included whenever the high-speed train track is at-grade and adjacent to (within 30 feet [9.1 meters]) existing freight and passenger rail operations on dedicated portions of the high-speed train line (or alternative). Containment walls are also required adjacent to existing structures where prescribed by horizontal clearances (Caltrans Bridge and American Railway Engineering and Maintenance-of-Way Association [AREMA] Standards).

Grade Separations

Bridges and Undercrossings: These are highway and railroad overcrossings/undercrossings of the high-speed train system. All crossings with other transportation facilities must be grade-separated from the high-speed train system. The unit costs applied for these grade separations include all of the cost elements necessary to complete the construction of the grade separations, such as earthwork, traffic handling, drainage, etc. The number of existing crossings (roadway and rail) per segment was quantified per USGS planimetric information, field reconnaissance and other mapping sources according to type (at-grade, under or over) and general land use density category (Dense Urban, Urban, Dense Suburban, Suburban & Undeveloped). Professional judgments were made regarding the proposed crossing type, including the option of closure for

minor roadways, based on aerial photography and mapping. Costs were estimated on a per-crossing basis using a representative unit cost.

Building Items

Costs for all building such as station facilities are based on the conceptual designs defined in the *Engineering Criteria Report*, January 2000.

Intermediate/Terminal Passenger Stations: Different Passenger Station facility unit costs were developed for several station classifications. The different unit costs account for differences in station size, configuration and general location. These costs are assumed to be a rough average, since station costs are expected to vary widely at specific locations.

Passenger Station: This includes cost of passenger platform and inspections platform (for certain stations) and also include tracks and special tracks going through stations plus substructure supporting tracks and platform outside of the main line track envelops. This cost also includes circulation, lighting, security measures and all auxiliary spaces including intermodal connection areas. Spaces are provided within the station for ticket sales, passenger information, station administration, baggage handling, and commercial space for newsstands, small restaurants, etc. Cost does not include cost of traction power, Overhead Catenary System OCS and signal and communication.

The estimated total costs for the Intermediate/Terminal Passenger station presented in Table E-2. Passenger Station cost breakdown is presented in Appendix G.

Table E-2
High-Speed Train Passenger Station Cost

Station		EIR/EIS Unit Cost
Terminal Station		
San Francisco 4th & King Station (Segment 2 - Caltrain Urban Tunnel)	ea	$437,517,500
West Oakland Station (Segment 4 - Urban Tunnel)	ea	$335,903,500
Oakland City Center Station (Segment 5 - Urban Tunnel)	ea	$335,903,500
Sacramento Downtown Depot Station (Urban - Aerial)	ea	$224,227,000
Sacramento Power Inn Road Station (Urban - Aerial)	ea	$224,227,000
San Diego Qualcomm Station (Urban - Aerial)	ea	$115,172,500
San Diego Airport Station (Urban - Aerial)	ea	$115,172,500
San Diego Downtown Station (Urban - Aerial)	ea	$114,977,000
Los Angeles Airport Station (Urban - Tunnel)	ea	$335,903,500
Anaheim Station (Urban - Tunnel)	ea	$335,903,500
Irvine Station (Urban - Tunnel)	ea	$335,903,500
Terminal/Intermediate Station		
Existing LAUS with South Connection (Urban - Aerial)	ea	$96,324,000
Existing LAUS with East Connection (Urban - Aerial)	ea	$96,324,000
LAUS South (Urban - Aerial)	ea	$96,324,000
LAUS East Bank (Over 110-Fwy Variant) (Urban - Aerial)	ea	$96,324,000
LAUS East Bank (Under 110-Fwy Variant) (Urban - Aerial)	ea	$96,324,000
San Jose Diridon Station (Segment 9 - Urban - Aerial)	ea	$93,437,500
Intermediate Station		
San Francisco Airport Station (Segment 3 - Urban)*	ea	$10,000,000
Palo Alto/Redwood City Station (Segment 3 - Suburban)*	ea	$10,000,000

Station		EIR/EIS Unit Cost
Santa Clara Station - (Segment 3 Optional - Urban)*	ea	$10,000,000
Oakland Airport/Coliseum Station (Segment 6 - Urban - At-Grade)	ea	$26,979,000
Union City Station (Segment 7 - Suburban - At-Grade)	ea	$28,669,500
Union City Station (Segment 8 - Suburban - At-Grade)	ea	$28,669,500
Auto Mall Parkway (Mulford) Station (Suburban - At-Grade)	ea	$28,669,500
Gilroy Station (Segment 12 - Undeveloped - Aerial)	ea	$75,624,000
Los Banos Station (Segment 13 - Undeveloped - At-Grade)	ea	$28,715,500
Morgan Hill Station (Segment 14 - Suburban - Aerial)	ea	$166,094,500
Stockton Downtown (ACE) Station (Suburban)*	ea	$10,000,000
Modesto Downtown Station (Suburban - Aerial)	ea	$165,048,000
Amtrak Briggsmore Station (Suburban - At-Grade)	ea	$32,430,000
Merced Downtown Station (Suburban - At-Grade)	ea	$32,430,000
Merced Municipal Airport Station (Suburban - At-Grade)	ea	$32,430,000
Castle Air Force Base Station (Suburban - At-Grade)	ea	$32,430,000
Fresno Downtown Station (Urban - At-Grade)	ea	$32,522,000
Visalia Airport Station (Undeveloped - At-Grade)	ea	$28,715,500
Hanford Station (Undeveloped - At-Grade)	ea	$28,715,500
Bakersfield Airport Station (Suburban - At-Grade)	ea	$32,430,000
Bakersfield Golden State Station (Urban - At-Grade)	ea	$32,211,500
Bakersfield - Truxton Union Avenue Station (Urban - At-Grade)	ea	$32,430,000
Bakersfield - Truxton Amtrak Station (Urban - Aerial)	ea	$165,048,000
Palmdale Transportation Center (Suburban - At-Grade)	ea	$32,430,000
Sylmar Station (Urban - Aerial)	ea	$171,844,500
Burbank Airport Station (Urban - Trench)	ea	$366,068,000
Burbank Downtown Station (Metrolink/UPRR Variant) (Urban - Aerial)	ea	$171,844,500
Burbank Downtown Station (I-5 Variant) (Urban - Aerial)	ea	$171,844,500
El Monte Station (Suburban - At-Grade)	ea	$26,979,000
Pomona Station (Suburban - Aerial)	ea	$164,703,000
Ontario Station (Urban - At-Grade)	ea	$26,979,000
Colton Station (Suburban - At-Grade)	ea	$26,979,000
Riverside/UCR Station (Urban - Aerial)	ea	$86,388,000
South El Monte Station (Suburban - At-Grade)	ea	$26,979,000
City of Industry Station (Suburban - At-Grade)	ea	$28,704,000
San Bernardino Station (Urban - Aerial)	ea	$86,388,000
March ARB Station (Suburban - At-Grade)	ea	$26,979,000
Temecula/Murrieta Station (Suburban - Aerial)	ea	$164,703,000
Escondido (I-15) Station (Suburban - Aerial)	ea	$163,806,000
Escondido Transit Center (Suburban - Tunnel)	ea	$366,068,000
Mira Mesa Station (Suburban - Aerial)	ea	$163,806,000
University City Station (Suburban - At-Grade)	ea	$33,453,500
Norwalk LAUS-UP Santa Ana Station (Suburban - At-Grade)	ea	$28,704,000
Norwalk LOSSAN Shared Use Station*	ea	$10,000,000
Anaheim LOSSAN Shared Use Station*	ea	$10,000,000
Irvine LOSSAN Shared Use Station*	ea	$10,000,000

***Pending further estimation of shared use or local track station and subsequent project level analysis**

Parking: This includes all facility costs associated with the construction of parking structures and at grade parking lots including right of way.

Site Development: This cost involves the paving and landscaping of the site around the passenger station building. Also included in this cost is the provision of street and roadway modifications necessary to provide access to the site. Different site development unit costs are provided for several levels of station size, based on the forecasted ridership.

Rail and Utility Relocation

Railroad Relocation and Removal: This involves the cost of track relocations (temporary or permanent) or track removal required to place high-speed train track into existing rail corridors, including all construction work needed to relocate or remove the railroad, including earthwork, trackwork, etc. A unit cost was applied to the length of alignment requiring relocation or removal.

Utility Relocation: The cost of major utility relocations that must be done before constructing the facilities, such as overhead power lines, pipelines, sewers and fiberoptics and underground ductbanks. Different unit costs were applied to the total length of alignment based on the intensity of land use development along the alignment.

B. RIGHT-OF-WAY ITEMS

This relates to the total cost associated with the purchase of land and/or easement rights for the high-speed train system. This includes relocation assistance and demolition costs. Property values and acquisition costs can range from quite modest in undeveloped areas, to quite significant in areas where high-value commercial properties near the stations are needed. These costs include those for title searches, appraisals, legal fees, title insurance, surveys, and various other processes.

The basic unit cost estimates assume that a minimum right-of-way width of 50 feet (15.2 meters) would be necessary throughout the length of each segment. Even when the alignment is primarily within existing rail rights-of-way, costs are estimated to account for the purchase and or lease agreements necessary for operation in these corridors. Wider right-of-way sections are necessary in mountainous areas where large cut and fill slopes are required.

Three general parameters were followed: (1) a minimum right-of-way corridor of 50 feet (15.2 meters) has been assumed in congested corridors; (2) a 100-foot (30.4-meter) corridor has been assumed in less developed areas to allow for drainage, future expansion and maintenance needs; and (3) a wider corridor was used in variable terrain to allow for cut and fill slopes, based on computerized terrain modeling of the alignment options.

C. ENVIRONMENTAL IMPACT MITIGATION

This cost is total cost associated with potential mitigation of environmental impacts such as impacts to wetlands, parkland, biological resources, and wildlife habitat. Noise mitigation with sound walls and right-of-way impact and relocation mitigation are estimated separately as defined above.

The total cost of environmental mitigation was estimated to be 3% of the line construction costs (i.e., track, earthwork, structures, etc.) for each segment, based on other recently implemented transportation corridors in California. This factor is based on the average to estimate a total cost of mitigation.

D. SYSTEM ELEMENTS

Signaling and Communications Items

Signaling: These costs cover the cost of wayside, on-board and central control software and hardware for the overall signaling system. The unit costs are applied per length of track. The VHS technologies operate either on the basis of moving block technology with automatic train protection (ATP) or automatic train control (ATC) and automatic train operation (ATO).

Communications: This includes a high capacity fiber optic backbone with full redundancy, which is key for the operation of the Supervisory Control and Data Acquisition (SCADA) and reliable ATC systems. The communication system would be used for operations; maintenance and emergencies; phone and fax capabilities (enroute); closed circuit television; public information systems; public address systems; and other monitoring and detection devices needed for a safe and efficient operating system. The unit costs are applied per length of track.

Wayside Protection Systems: This includes systems/equipment to monitor and/or detect obstacles that may be placed or fall onto the track; intrusion; flooding; wind; seismic activity and equipment failures (broken rails, hot axles, dragging equipment, etc.). The unit costs are applied per length of track.

Electrification Items

Traction Power Supply: This cost is the entire cost of the substations, including site preparation; foundations; cable trenches; fencing; electrical equipment, etc. The unit costs are applied per unit length of track. It does not include the cost of transmission lines from the local utility source to the substations; those are included in the energy costs, a part of the operating and maintenance costs

Traction Power Distribution: This cost includes the catenary poles and foundations; the catenary wires and supports; tensioning devices; power feeders and returns; transformers and other appurtenances. The unit costs are applied per unit length of track.

E. VEHICLE COSTS

This includes costs for trainsets including an inventory of small parts estimated to be needed for regular maintenance. The costs are based on an estimated fleet size to accommodate the high-end ridership forecasts according to the conceptual operating plan, including estimated spare/out of service requirements. This unit cost includes a 15% contingency to account for uncertainties related to the variance of cost between manufacturers, burn-in and testing and other economic uncertainties at this stage of estimation.

The unit cost estimates for each train set are based upon published manufacturers' documentation on recent sales of in-service trainsets at the time of the preparation of this document, as well as telephone inquiries with representatives of the manufacturer. Five manufacturers were considered to develop the unit costs, which are representative of the different manufacturers cost information.

F. SUPPORT FACILITY COSTS

Costs for all support facilities are based on the conceptual designs defined in the Engineering Criteria Report. The support facilities include the Train Storage, Service and Inspection, and Light Maintenance Facilities defined near the terminal stations at Sacramento, the Bay Area (at Los Banos due to land use constraints in the Bay Area), and San Diego. They also include the Main Repair and

Maintenance Facility to be located in the mid-portion of the system (Central Valley). The configurations of these facilities are summarized below.

Sacramento: The revised storage yard concept is located approximately 13 kilometers from Sacramento Terminal Station (south of Alpine Avenue, north of Elder Creek Road, east of Power Inn Road, west of Florin Perkins and parallel to the UPRR main track alignment). This arrangement provides track lengths that accommodate one 400 meter train set or two 200 meter train sets on each track. It provides a configuration which supports the conceptual service plan (nine train sets). The revised storage yard concept is composed of eleven tracks, and assumes inclusion of a wheel truer, train washer and S&I facility.

Bay Area (Los Banos): The revised storage yard concept is located approximately 197 kilometers from San Francisco/Transbay Terminal Station (immediately west of where Highway 165 intersects with Henry Miller Avenue and parallel with Henry Miller Avenue). This arrangement is based upon track lengths that accommodate one 400 meter train set or two 200 meter train sets on each track. It provides the configuration which supports the conceptual service plan (fifteen train sets). The revised storage yard concept is composed of sixteen tracks, and assumes inclusion of a wheel truer, train washer and S&I facility.

San Diego: The new storage yard concept is located approximately 8 kilometers from San Diego Terminal Station (Qualcomm option; immediately north of the Soledad Freeway and parallel to the Escondido Freeway). This arrangement is based upon track lengths that accommodate one 400 meter trainset or two 200 meter trainsets on each track. It provides the configuration which supports the conceptual service (twenty-one trainsets) plan (from the Corridor Evaluation Study) with dimensions that are a combination of the shortest length and greatest width. The revised storage yard concept is composed of twenty three tracks, and includes a wheel truer, train washer and S&I facility.

The costs include all costs associated with support maintenance facilities, including right of way and facilities. In addition to civil work and structural work, the unit cost includes trackwork, traction power, OCS and signal and communication and also maintenance equipment costs.

The estimated capital costs for these facilities are presented in Table E-3. Storage Yard and Maintenance Facility breakdown cost is presented in Appendix H.

Table E-3
Storage Yard & Maintenance Facility Cost

Maintenance Facility	Construction Cost	Right-of-way	Right-of-way Cost	Total Cost
		Hectares		
Storage Yard & Maintenance Facility				
Sacramento	$74,950,000	9.40	$21,927,650	$96,877,650
San Diego	$112,540,000	14.70	$34,291,113	$146,831,113

Bay Area (Los Banos)	$84,540,000	10.00	$2,915,910	$87,455,910
Main Repair & Storage Yard Facility				
Near Los Angeles, Bakersfield, Fresno or Merced	$248,820,000	39.84	$11,616,987	$296,436,987

The facilities sizing was based on the greatest potential need (fleet size) associated with various operating scenarios. These operating scenarios are based on the Business Plan Sensitivity Analysis ridership forecasts, which represent the highest reasonable forecasted ridership, and the conceptual service plan from the Corridor Evaluation. For the purposes of defining these general facilities, we have assumed the following trainset storage requirements: Sacramento (9 trains), San Francisco/Oakland (15 trains), San Diego (21 trains), Los Angeles (4 trains), Fresno and Bakersfield (2 trains).

G. PROGRAM IMPLEMENTATION COSTS

Costs for these elements are computed as a percentage of the total of construction and procurement costs. The percentages are intended to represent the average overall cost of these implementation items, based on implementation of rail transit and other related improvement projects throughout the state. The percentages are predicated on a Design-Build (DB) and Design-Build-Operate-and-Maintain (DBOM) procurement approach and would be significantly higher using a traditional procurement approach. These costs would be divided between the owner and the contractor in this procurement approach and are noted accordingly. These costs should be included in the cost estimates for overall consistency in the order of magnitude.

Preliminary Engineering and Environmental Review

These are preliminary engineering design costs to approximately a 35% level. This would includes preliminary geotechnical investigations; land surveying and mapping; engineering; architecture; landscape architecture; traffic engineering; right-of-way engineering and preparation of preliminary plans and analyses in all necessary technical disciplines; and various other technical studies and support of the draft environmental document. The environmental review would entail all studies and analyses necessary to complete further federal and state required environmental documents. (Owner–2.5%)

Program & Design Management

Costs for the overall management and administration of the project. Included were the Program Manager's office, contract management and administration, project control including both cost and schedule, general administration, computer support, quality assurance, configuration management, system safety, publications, public relations, support of the bidding process, agency liaison, community information and involvement and legal support. (Owner–5.0%)

Final Design

Costs for final design and preparation of construction and procurement documents for all facilities and systems. This would include geotechnical investigations; land surveying and mapping; engineering; architecture; landscape architecture; traffic engineering; right-of-way engineering; preparation of plans and specifications in all necessary technical disciplines; and various other technical studies and support of the final design process. Design support during construction, including shop drawing review is also included in this item. (Contractor–5.0%)

Construction & Procurement Management

Costs for all management of construction and procurement work after contracts are awarded to contractors or suppliers. This would include on-site inspection in factory and field, quality control, contract administration and acceptance inspection. (Owner–1.0%; Contractor–4.0%)

Agency Costs

The costs of maintaining the owner's organization (or operator of the system) during the entire program, whether that owner is a franchisee or a government agency. (Owner–1.0%)

Force Account Costs

Costs for the services of other organizations or agencies of local, state or federal government that may be required to support the project. Work within railroad rights-of-way may be on force account with the appropriate railroad. There may be unforeseen costs as a result of moving the railroad to allow for high-speed trains. (Owner–1.0%)

Risk Management

The costs of owner (or operator of the system)-supplied insurance or any other allowances decided to be applied for the management of risk to the owner. (Owner–6.0%)

Testing & Pre-Revenue Operations

The costs of pre-revenue testing, acceptance testing, safety certification and training related to start-up of the system for revenue service. These costs would be included in the DBOM contract. These costs are not included as part of the program implementation costs at this level of evaluation.

H. CONTINGENCIES

A contingency is added as a percentage of overall project costs—based on past experience for projects in early stages of definition. Contingencies should not be considered as potential savings. They are an allowance added to a basic estimate to account for items and conditions that cannot be assessed at the time of the estimate. The contingency amount is expected to be reduced as the project matures. The contingency is estimated at 25% of the total of construction costs.

Unit Costs

#.1.3 Adjustments to Unit Costs

The revised unit costs are based on the unit costs applied in the Business Plan cost estimate in 2000. The unit costs were adjusted to account for inflation from 2000 to September 2003, based on the Engineering News Record (ENR) Construction Cost Index Report. In addition, adjustments were made to the tunneling unit costs, based on the outcome of the Tunneling Conference held in December, 2001.

Tunneling Conference

To provide a forum to address the issues associated with the tunneling required for the statewide high-speed train system, a technical conference was held on December 3 and 4, 2001, in the Los Angeles area. The conference was attended by seven representatives of major tunneling contractors, nine specialized tunneling consulting engineers, two geologists/geotechnical engineers, and representatives of the Program Management and Regional Study Teams as well as Authority staff. In addition, the first day of the conference was observed by two Authority Board Members. The conference was held over a two day period providing sufficient time for extensive discussion in the three main areas: past assumptions and requirements, construction methods and cost estimating.

The conference focused on gaining insights/input regarding feasibility, construction methods and cost assumptions associated with the proposed tunneling. This information will be used in making planning decisions that are based on the current construction capabilities or those reasonably expected within the implementation timeframe of this project. The attendees were provided with background information on the studies to date, system requirements, previous assumptions, and previous findings as a basis for participation in the technical conference. As part of the conference, attendees participated in discussions and cost estimating exercises to identify and explore the key issues.

Conclusions

Based on the outcome of the discussions held throughout the conference, numerous specific conclusions were formalized with all of the attendees. Several of the key conclusions are summarized below.

- Confirmed the overall feasibility of the tunneling proposed for the statewide high-speed train system. No 'fatal flaws' were identified in the tunneling assumptions applied to date.
- Tunnel boring machines should be assumed as the excavation method for all tunnels with the exception of specific areas identified during the conference that have difficult geology.
- Twin single track tunnels should be assumed for lengths of 0-6 miles. For lengths greater than 6 miles a third tunnel is required for ventilation, evacuation and construction access.
- There is no significant difference in the tunneling requirements (methods or cost) at sustained 2.5% or 3.5% vertical grades.
- The cost of tunneling using Tunnel Boring Machines versus Drill and Blast methods was not as significant as the difference in construction time. Drill and Blast methods require significantly more time.
- All tunnels should be fully lined for structural, water tightness and aerodynamic reasons.
- Considerable geologic exploration is required prior to construction.
- Consider reducing the cross-sectional area of tunnels approaching terminal stations and evaluate potential reductions in other areas. Tunnel cost is directly related to the diameter of the tunnel, which is determined by the design speed through the tunnel.
- Confirmed the desirability of crossing of major fault zones at grade.
- Confirmed the objective of minimizing the amount of tunneling required, due to cost, time of construction and potential for delay.
- Limit the use of long tunnels (over 12 miles in total length).

The conclusions reached at the conference generally confirm and support the studies completed to date. Conclusions representing new information or direction have been incorporated into the conceptual design of alignment options, the definition and assumptions of the cost tunneling cost elements, and the tunneling unit costs.

During the course of the tunneling conference, the attendees were asked to prepare rough estimates of tunneling unit costs for comparison and discussion purposes. These estimates are presented and compared to the previous Authority assumptions in Table E-4. These costs do not reflect a true "apples to apples" comparison, since they are not based on all of the same assumptions. The previous tunneling related unit costs were revised to better reflect the same assumptions and account for the findings of the tunneling conference and subsequent research and analysis. The revisions shown in Table E-4 reflect adjustments made to the costs at the time of the conference to account for the following:

- Inflation to 2001 dollars.
- The addition of full tunnel lining including membrane and grouting (contact and formation).
- Removal of implementation cost add-on factor (to be included in the overall estimate).
- Removal of electrical and mechanical items (to be included in the overall estimate).
- Adjustment for new assumed advance rates.

These tunneling unit costs were subsequently inflated to September 2003 cost levels.

Table E-4
Tunneling Unit Cost Comparison Table

Cost Elements		1999* HSRA Per Screening Methodology $/mile	2001* HSRA Adjusted per tunnel Conference (w/Lining & revised advance rates) $/mile	2001* Conference Average (with lining) Average $/mile	Range $/mile
Item #	**Structure Type**				
6	Twin Single Track Drill & Blast (<6 Miles)	$113,838,200	$145,728,000	$130,680,000	$95-159,000,000
7	Twin Single Track TBM (<6 Miles)	$76,153,000	$107,712,000	$116,160,000	$85-148,000,000
8	Twin Single Track TBM w/3rd Tube (>6 Miles)	N/A	$153,120,000	$155,232,000	$127-175,000,000
9	Double Track Drill & Blast	$57,987,650	$162,624,000	$174,768,000	$95-326,000,000
10	Double Track Mined (Soft Soil)	$155,617,000	$186,912,000	$132,000,000	$106-132,000,000
11	Seismic Chamber (Drill & Blast/Mined) (3600' Long x 77' wide x 37' high)	$91,323,400	$114,400,000	$114,400,000	$81-150,000,000
12	Crossovers (each)	N/A	$114,400,000	N/A	
13	Cut & Cover Double Track Tunnel	$50,763,650	$93,456,000		

* All Unit Costs include 25% Contingency and 25.5% Program Implementation Cost Add-ons

The unit costs for all elements described above are presented in Table E-5.

Table E-5
High-Speed Train Unit Cost

Cost Elements		Unit	Unit Price (YR Sept. 2003)
ALIGNMENT COST			
Track Items			
1	Double Track Section–Total	km	
2	Double Track Section–At-Grade	km	$846,282
3	Double Track Section–On Structure	km	$1,600,459
4	Double Track Section–In Tunnel or Subway	km	$1,600,459
5	Double Track Section–In Trench	km	$1,600,459
6	Single Track Sections–In Tunnel or Subway	km	$1,000,287
7	Freight Double Track–At-Grade	km	$846,282
8	Freight Single Track–At-Grade	km	$423,141
9	Four-track construction or reconstruction	km	$1,692,564
Earthwork Items			
1	Site Preparation–Undeveloped	Hectares	$10,294
2	Total Cut	m3	$7.59
3	Total Fill	m3	$7.59
4	Landscape/Erosion Control	Hectares	$6,881
5	Security Fencing (Both Sides of R/W)	km	$86,687
6	Special Drainage Facilities	5% of Earthwork Cost	
Structures, Tunnels, Walls			
1	Standard Structure	km	$11,702,749
2	High Structure	km	$14,043,299
3	Long Span Structure	km	$32,020,021
4	Waterway Crossing–Primary	km	$24,606,000
5	Waterway Crossing–Secondary (Irrigation/Canal Crossing)	km	$19,700,000
6	Twin Single Track Drill & Blast (<6 Miles)	km	$63,942,150
7	Twin Single Track TBM (<6 Miles)	km	$47,261,589
8	Twin Single Track TBM w/3rd Tube (>6 Miles)	km	$67,185,592
9	Double Track Drill & Blast	km	$71,355,733
10	Double Track Mined (Soft Soil)	km	$82,012,758
11	Seismic Chamber (Drill & Blast/Mined)	ea	$80,782,844
12	Crossovers	ea	$80,782,844
13	Cut & Cover Double Track Tunnel	km	$41,006,379
14	Trench Short	km	$42,322,835
15	Trench Long	km	$33,464,567
16	Mechanical & Electrical for Tunnels	km	$1,645,723
17	Retaining Walls	km	$3,749,214
18	Containment Walls	km	$1,278,634
19	Single Track Cut and Cover Subway	km	$25,628,987

	Cost Elements	Unit	Unit Price (YR Sept. 2003)
Grade Separations			
1	Street Overcrossing HSR–(Urban)	ea	$14,628,436
2	Street Overcrossing HSR–(Suburban)	ea	$5,526,298
3	Street Overcrossing HSR–(Undeveloped)	ea	$931,886
4	Street Undercrossing HSR–(Urban)	ea	$15,278,589
5	Street Undercrossing HSR–(Suburban)	ea	$5,851,374
6	Street Undercrossing HSR–(Undeveloped)	ea	$986,065
7	Street Bridging HSR Trench	ea	N/A
8	Minor crossing closures	ea	$151,702
Building Items			
1	Terminal	LS	$95,355,731
2	Site Development/Parking (Terminal Station)	LS	$23,838,933
3	Urban	LS	$47,677,865
4	Site Development/Parking (Urban Station)	LS	$11,919,466
5	Suburban	LS	$23,838,933
6	Site Development/Parking (Suburban Station)	LS	$5,959,733
7	Rural	LS	$11,919,466
8	Site Development/Parking (Rural Station)	LS	$2,383,893
9	Parking–Structure	space	$14,244
10	Parking–At Grade	space	$2,042
Rail and Utility Relocation			
1	Single Track Relocation (Temporary)	km	$1,083,588
2	Single Track Relocation (Permanent)	km	$1,083,588
3	Single Track Removal	km	$54,000
4	Major Utility Relocations–Dense Urban	km	$758,511
5	Major Utility Relocations–Urban	km	$579,719
6	Major Utility Relocations–Dense Suburban	km	$406,345
7	Major Utility Relocations–Suburban	km	$232,971
8	Major Utility Relocations–Undeveloped	km	$11,919
Right of Way Items			
1	Right-of-Way Required for Each Segment		
	Dense Urban	Hectares	$3,499,093
	Urban	Hectares	$2,332,729
	Dense Suburban	Hectares	$1,166,364
	Suburban	Hectares	$408,227
	Undeveloped	Hectares	$291,591
2	Right-of-Way Required for Passenger Station & Parking Facilities		
	Dense Urban	Hectares	$3,499,093
	Urban	Hectares	$2,332,729

Cost Elements		Unit	Unit Price (YR Sept. 2003)
	Dense Suburban	Hectares	$1,166,364
	Suburban	Hectares	$408,227
	Undeveloped	Hectares	$291,591
Environmental Mitigation			
Environmental Mitigation		3% of Line Cost	
System Elements			
1	Signaling (ATC)	km	$720,586
2	Communications (w/Fiber Optic Backbone)	km	$595,973
3	Wayside Protection System	km	$57,213
Electrification Items			
1	Traction Power Supply	km	$368,420
2	Traction Power Distribution	km	$686,995
Vehicle Costs			
1	Fleet size estimate	Trainset	$44,000,000
Program Implementation Costs			
Program Implementation Costs		25.5% of Total Cost & Procurement	
Contingencies			
Contingencies		25% of Total Construction Cost	